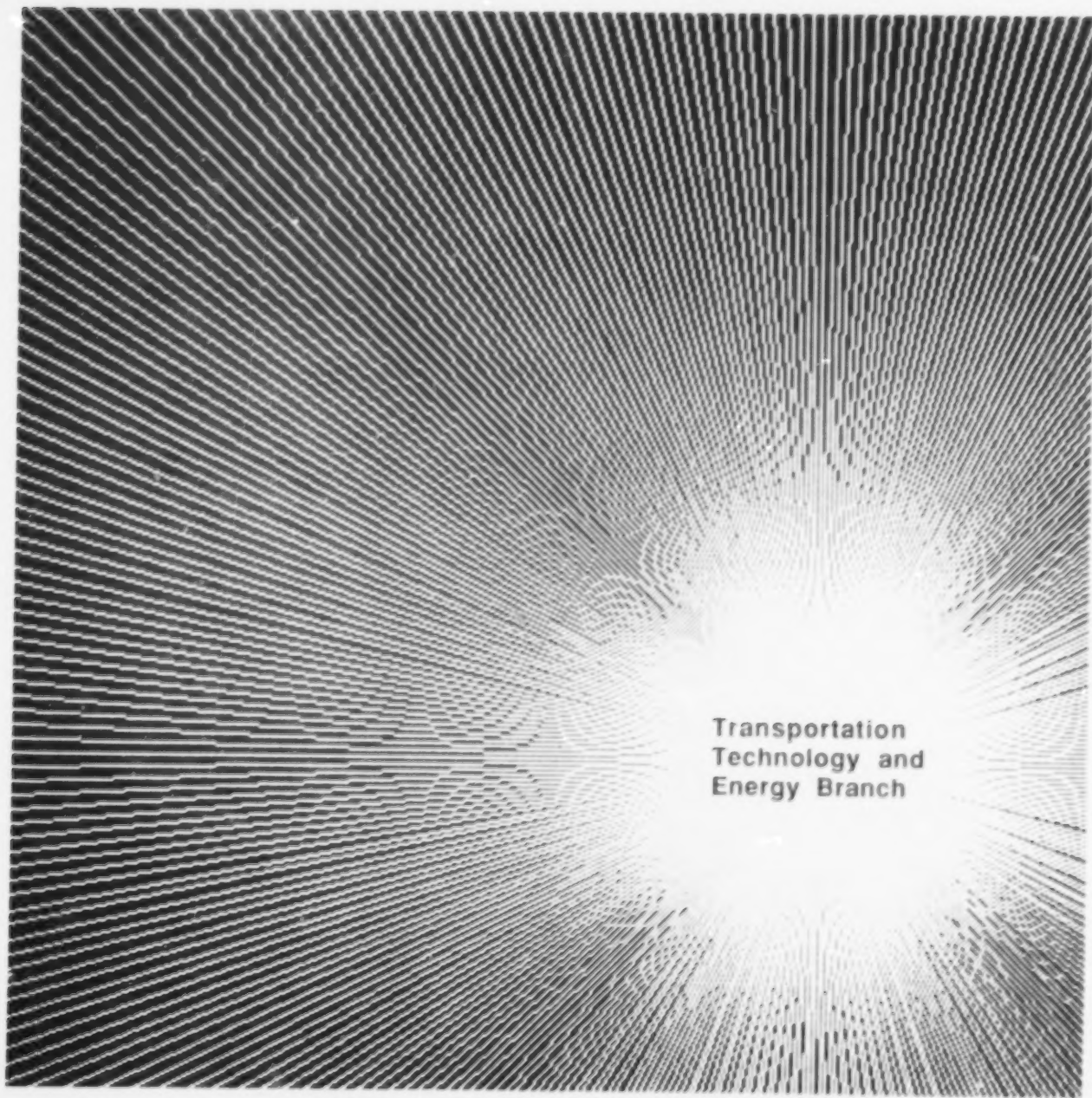




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Aggregate Truck Load Shift Experiment

CV-90-01

Aggregate Truck Load Shift Experiment

Prepared by: **J.R. Billing**

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Abstract: A limited experiment examined the tendency of truck loads of aggregate to shift during transportation between the quarry and a truck inspection station.

Four loads of aggregate, judged most likely to shift, by aggregate producers and aggregate carriers, were weighed and measured at various points during the trip.

Vibration during transportation caused a general uniform downward settlement of each load. Even an abrupt stop could only move a minor quantity of the load. No significant changes in truck axle load were observed as a consequence of transportation.

It was concluded that load shift was a possible, but unlikely, cause of axle overloads. The original load distribution remained the most likely cause.

Key words: truck, aggregates, load, load shift, axle weights, compliance

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Aggregate Truck Load Shift Experiment

J.R. Billing
Vehicle Technology Office

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EXECUTIVE SUMMARY

Aggregate carriers have expressed concern that it is difficult to load their trucks close to the allowable gross weight while not exceeding the allowable axle weights. One reason suggested for this was that the load may be susceptible to shift during transportation.

A limited experiment was designed to examine the tendency for truck loads of aggregate to shift during transportation between the quarry and a Ministry truck inspection station. Two loads of each of the two aggregates judged most likely to shift by aggregate producers and carriers were used. The load profile inside the trailer box was measured, and axles were weighed at the quarry, on arrival at the truck inspection station, and after an abrupt stop. The entire process was recorded on video tape. There was little difference in the behaviour of the four loads.

Vibration during transportation resulted in a general downward settlement, with little apparent shift either forward or rearward. No significant changes in axle load were observed during the experiment. Even the abrupt stop only caused a very minor shift of insufficient mass to cause perceptible change in axle loads.

It was concluded that the most likely cause of axle overweight for an aggregate carrier within the allowable gross weight, and with the proper load on any liftable axle, would be the original load distribution, rather than load shift. While this limited experiment cannot rule out the occasional load shift, it does suggest it should be an infrequent exception rather than the rule.

The video tape taken during the experiment has been edited to provide a narrated visual record of the observations.

1/ INTRODUCTION

Aggregate carriers have expressed concern that it is difficult to load their trucks close to the allowable gross weight while not exceeding the allowable axle weights. The Government/Aggregate Industry Weight Review Committee was convened by the Ministry of Transportation of Ontario (MTO), so that the Ministry could address such concerns cooperatively with all parties involved in transportation of aggregates. The committee was offered many issues that might contribute to difficulty in complying with axle weight legislation. One of these was that the load may be susceptible to shift during transportation.

A limited experiment was designed to examine the tendency for load shift during normal transportation of aggregates from a quarry to a Ministry truck inspection station. The Committee advised that the experiment should consider only natural materials, and that it should be conducted using materials from quarries both to the east and to the west of Toronto.

Arrangements were made for the first stage to be conducted on August 22, 1989 using material from United Aggregates quarry at Caledon, with Petrella Transport as the carrier. The vehicle proceeded from the quarry to the Ministry truck inspection station at Victoria on Highway 10, a distance of 11 km.

The second stage was conducted the following day using material from TRT Sand and Gravel quarry at Mosport, with Harold L. Wood Transport as the carrier. The vehicle proceeded from the quarry, using Highway 35, to the Ministry truck inspection station at Bowmanville on Highway 401, a distance of 27 km.

2/ DEFINITIONS

The following definitions are provided for the purpose of clarity of this report.

"Load movement" means load settlement or load shift.

"Load settlement" means a general downward migration of stones in the load.

"Load shift" means a general longitudinal migration of stones in the load.

Settlement implies compaction of the load, as illustrated in Figure 1. Load shift implies pure migration of stones, without any compaction. It may be symmetric or asymmetric, as illustrated in Figures 2 and 3 respectively.

A particular load is expected to experience settlement, symmetric shift, and asymmetric shift during different phases of the same trip. Shift may also occur generally longitudinally, generally transversely, or in both directions.

3/ PROCEDURE

The trucks used were both tractor-semitrailers, where the so-called "tri-axle" semitrailers had a fixed dual axle unit and a single liftable axle. The two trucks and their dimensions are shown in Figures 4 and 5. Both tractors had high front axle ratings, and each was configured to operate with its front axle load consistently in excess of 5500 kg. Most tractors have fifth wheels set less far forward, which results in an average front axle load of about 5100 kg (11240 lb). There were detail differences in trailer design that were significant for the experiment. Petrella Transport's trailer had its box set 0.51 m (20 in) back from the kingpin. This required the load to be piled relatively high against the head of the trailer to achieve proper loading of the drive axles, as shown in Figure 6. In contrast, Harold L. Wood Transport's trailer had its kingpin set 0.51 m (20 in) back from the front of the box. The 1.02 m (40 in) rearward setting of the kingpin in this trailer allowed a somewhat more uniform loading, with the peak of the load more centrally located in the box, as shown in Figure 7. The load in both Figures 6 and 7 shows a distinct bias to the right side of the trailer, perhaps because both trucks were loaded from the left-hand side.

Two trips were made on each day, using the same truck, driver, and procedure for each. After consultation between representatives of the aggregate producer and the carrier, materials most susceptible to shift were selected. Different materials were taken on each trip. A sample of each material was taken for analysis of its properties.

The following procedure was followed to gather data from each trip:

- 1/ Observe the normal process of loading the vehicle, shown in Figure 8, and record it on video tape.
- 2/ Take a sample of the material for analysis.
- 3/ Move the vehicle very carefully to level ground near the point of loading for the next stage.
- 4/ Weigh all axles of the truck by means of portable scales, with any liftable axles in the raised position, as shown in Figure 9. Record the weights. Also record the scale locations, so that the same scale is always used to weigh the same wheel.
- 5/ Measure and record the height of the load in the box at intervals of approximately one metre around the perimeter of the box, as shown in Figure 10.
- 6/ Spray paint a line to mark the load profile inside the box, as seen in Figure 11.
- 7/ Record steps 4, 5, and 6 on video tape.
- 8/ The truck now proceeds in the normal manner to a Ministry truck inspection station.
- 9/ Repeat steps 4, 5, 6, and 7, with the truck parked on a flat surface at the inspection station.
- 10/ Install the braking decelerometer shown in Figure 12 in the truck, lower the liftable axle, and bring it to the correct load. Back as far as is safe into the approach to the inspection station, accelerate as space permits, and brake to an abrupt stop. The stop should be as hard as possible, but without risk to persons or property.

- 11/ Return the truck to the same flat surface used for step 9.
- 12/ Repeat steps 4, 5, 6, and 7.
- 13/ The truck is released to deliver its load. It was not planned to follow the truck to its destination; however, it was an option if it appeared desirable. Steps 3 through 7 would be repeated at the destination.

Figure 13 shows a general view of activity at the Bowmanville truck inspection station, including video-taping and measuring the load profile inside the box, and preparation for weighing.

4/ RESULTS

4.1/ Trip 1

Trip 1 was made from United Aggregates quarry at Caledon, with Petrella Transport as the carrier and a load of 3/4-inch round stone. United Aggregates conducted an analysis of a sample of the load, and reported it to consist of 93.97% coarse aggregate and 6.03% fine aggregate. It had a moisture content of 2.22% and 94.47% of the mass passed a 19.0 mm (3/4 in) sieve. The report estimated the sample contained less than 5% crushed stones, and 4 to 5% of elongated and flat stones. The vehicle travelled 11 km from the quarry to the Ministry truck inspection station at Victoria on Highway 10.

The load profile was measured on both sides of the trailer, from the front to the rear of the box, at the locations of the stiffening ribs on the exterior of the trailer. These were at intervals of approximately one metre. The load profile was measured downwards, in inches, from the top of the rub board on the box to the top of the load. The measuring instrument was fitted with a small foot about 2 by 4 cm (3/4 by 1 1/2 in) to rest on the stones without penetration, as seen in Figure 10. No attempt was made to measure the load profile in the interior of the dump box, as it was expected that load movement would appear as a change in load height at the sides of the box.

The load profile is presented in Table 1. The data have been inverted to present the load height from the trailer deck, a quantity that is more readily visualized than the distance from the top to the load. Note that there was bare deck at the rear of the trailer. The average deceleration recorded during the abrupt stop, 0.31 g, is also presented. This was a hard stop, at a level the driver estimated would occur no more frequently than once per week in normal driving, and below the level of a true emergency stop.

A review of Table 1 shows only small differences between measurements taken at various points of the trip. A graphic display of these data was not very helpful as the lines all blended together. Therefore, to illustrate the load movement, the difference between the load height at each stage of the trip, and the initial load height, is presented in Figure 14. Note that a negative value represents a reduction in height of the load.

The data in Table 1 shows that the load for Trip 1 was about the same height on both sides in the front half of the box, whereas it was much higher on the right-hand side in the rear half. The load movement pattern in Figure 12 shows a general settlement of 2-7 cm (1-3 in), combined with a transverse shift from right to left of 5-15 cm (2-6 in) in the rear of the trailer. The stop of 0.31 g resulted in an average forward shift of about 10 cm (4 in) over the first two metres of the box. The weight of material involved in this shift is estimated at about 425 kg (935 lb). It would move the centre of gravity of the

entire load only about 1 cm (0.4 in). This corresponds to a load shift of only 5 kg (11 lb) from the trailer axles to the tractor drive axles, a negligible change that is not within the resolution of the scales used in this experiment.

Each vehicle was weighed with its liftable axle raised, so that any change in pressure of its air suspension would not affect the results. Individual wheel weights were obtained from MTO wheel scales. Ten scales were used to weigh all wheels of the vehicle simultaneously. There were wheel load differences from left to right, which may be attributable both to load bias and to crossfall of the weighing surface. There were also differences between axles of an axle unit, which may be attributable to friction in the suspension interacting with the brakes as the vehicle stopped. In both cases, these differences cannot reasonably be quantified or rationalized. The wheel weights have therefore been added to provide axle unit weights that are comparable to those obtained from the scales at the MTO truck inspection station.

The axle unit and gross weights presented in Table 2 are fairly consistent at all stages of the experiment. Such differences and lack of pattern are typical from repeated weighing of the same load. The fact that the axle unit weights did not change reflects the observation reported above that the load appeared to settle downwards during transit, and did not shift significantly as a consequence of the abrupt stop.

4.2/ Trip 2

Trip 2 was also made from United Aggregates quarry at Caledon, with Petrella Transport as the carrier, but with a load of pea stone. United Aggregates conducted an analysis of a sample of the load, and reported it to consist of 95.47% coarse aggregate and 4.63% fine aggregate. It had a moisture content of 5.42% and 99.94% of the mass passed a 13.2 mm (1/2 in) sieve. The report estimated the sample contained less than 5% crushed stones, and 4 to 5% of elongated and flat stones. The vehicle also proceeded from the quarry to the Ministry truck inspection station at Victoria on Highway 10.

After Trip 1, the driver reported that there appeared to have been further movement of the load when he inspected it at his destination. On Trip 2, therefore, the test crew followed the truck to its destination, a further distance of about 30 km, and repeated the entire process there. There was a light rain shower while the truck was en route from the quarry to the Victoria truck inspection station. This was not considered to have any effect on the results.

The data in Table 3 shows that the load for Trip 2 was about the same height on both sides along the entire length of the box. The load movement pattern in Figure 15 shows a general settlement of about 5 cm (2 in) between stations 3 and 7, the central part of the load, with offsetting longitudinal shift of about the same magnitude at each

end. The stop of 0.31 g resulted in a forward shift of about 10 cm (4 in) over the first metre of the box.

Figure 16 shows the profile of this load at the quarry just after it was loaded, looking forward from the rear of the trailer. Notice the relatively steep peaks on the last two loader scoops. Figure 17 shows the same load on arrival at Victoria truck inspection station. The rounded shape of the two peaks at this point contrasts with their earlier shape, and is seen as a general settlement of the load. Notice also in Figure 17 the general settlement along both sides of the dump box, as shown by the clear difference between the load and the line spray painted at the quarry.

The axle loads for Trip 2 are presented in Table 4. The drive axle load at the quarry at the start is slightly low. This arose from a low reading on the right-hand wheel scale for the second drive axle, possibly because the tire was not quite centered on the weighing element of the scale. Otherwise, the results show good consistency throughout. The apparent rearward shift of 100 kg due to the stop is contrary to expectation. The apparent shift of 200 kg from trailer to drive axles is inconsistent with the heavy forward bias of the load, which would be expected to shift to the rear. Neither of these shifts, if real, is large enough to place the truck in a situation where an overweight charge would be laid.

4.3/ Trip 3

Trip 3 was made from TRT Sand and Gravel quarry at Mosport, with Harold L. Wood Transport as the carrier and a load of pea stone. The Ministry conducted an analysis of a sample of the load, and reported it to consist of 98.3% coarse aggregate and 1.7% fine aggregate. It had a moisture content of 1.5% and 98.3% of the mass passed a 13.2 mm (1/2 in) sieve. The vehicle travelled 27 km from the quarry, on Highway 35, to the Ministry truck inspection station at Bowmanville on Highway 401.

The data in Table 5 shows that the load was about 20-30 cm (8-12 in) higher on the right-hand side of the box than the left. The load-movement pattern in Figure 18 shows a general settlement of about 2-7 cm (1-3 in). The stop of 0.36 g resulted in a forward shift of about 10 cm (8 in) over the first metre of the box. Again, the weight of material that shifted was too small to affect axle loads.

The axle loads for Trip 3 are presented in Table 6, and generally reflect the same lack of pattern as those for Trips 1 and 2. All axle loads, and hence the gross weight, are low for the initial weighing at the quarry on wheel scales. It is believed that there may have been interference between the gravel surface on which the scales were placed, and the weighing element of some scales, once the scales were loaded. Such interference leads to an under-weighing.

The load from this trip was not useful to a client of the carrier, so was returned to the stockpile at the quarry. It was interesting to observe it being dumped. As the hoist tilted the box, only a few loose stones moved before the tilt reached about 20 degrees, which corresponds to a braking deceleration of 0.36 g. At that point, a slab of stones about 10-20 cm (4-8 in) in depth sheared off and slid out the tailgate. As the box moved higher, further slabs of stones sheared off, each apparently a little thicker than the last. The bulk of the load did not slide until the tilt reached about 30 degrees, as shown in Figure 19, which corresponds to a braking deceleration of 0.58 g. This simple demonstration required a box tilt similar to the highest deceleration the truck would normally see in a week to move a small mass of stones. Movement of the bulk of the stones, in a load judged susceptible to shift, did not occur until the tilt angle reached an equivalent deceleration at about the full capability of the truck. Dumping of other materials, such as crushed rock, which require greater tilt angles, implies less tendency to shift.

4.4/ Trip 4

Trip 4 was also made from TRT Sand and Gravel quarry at Mosport, with Harold L. Wood Transport as the carrier and a load of 3/4-inch round stone. The Ministry conducted an analysis of a sample of the load, and reported it to consist of 91.0% coarse aggregate and 9.0% fine aggregate. It had a moisture content of 1.5% and 97.0% of the mass passed a 19 mm (3/4 in) sieve. The vehicle also drove from the quarry to the Ministry truck inspection station at Bowmanville on Highway 401.

The data in Table 7 shows that the load was about 20-40 cm (8-16 in) higher on the right-hand side of the box than the left. The stop of 0.39 g resulted in a forward shift of about 10 cm (8 in) over the first two metres of the box, as seen in Figure 20. The weight of material involved in this shift is estimated at about 850 kg (1870 lb). It would move the centre of gravity of the entire load only about 2 cm (1 in), which again has a negligible effect on the axle loads. The load-movement pattern shown in Figure 21 shows a general settlement of about 2-5 cm (1-2 in).

The axle loads again lack pattern, as for the earlier trips. Again, all axle loads, and hence the gross, were low for the initial weighing at the quarry on wheel scales, possibly due to interference between the gravel surface on which the scales were placed, and the weighing element of some scales.

5/ DISCUSSION

Vibration of the trailer as it drove along the road is considered to be the cause of general load settlement. It is suggested that this vibration tends to cause neighbouring stones to align themselves so that the entire load occupies minimum space. If this is the case, the stones will presumably tend to lock together, which would inhibit the longitudinal movement necessary for a load shift to manifest itself by a change in axle loads.

There was little apparent shift, either forward or rearward. If the load settles uniformly, then the centre of gravity of the entire load does not move. If the load shifts symmetrically in a uniform manner, then the centre of gravity of the entire load also does not move. In either of these cases, because the load centre of gravity does not move, the axle loads do not change. No significant changes in axle load were observed during the experiment. The differences that did occur are within the uncertainty in weighing and are all well within the normal discretionary tolerance that Ministry inspection staff use during weight enforcement.

An abrupt stop, a hard stop below the level of an emergency stop, caused little apparent load shift where the load was heaped predominantly to the front of the trailer. Some load shift was apparent where the load was more uniformly distributed, with a cone towards the middle of the trailer. Only a shallow layer on top of the load shifted, and it had insufficient mass to be perceptible as a change in axle loads.

The four trips of this experiment certainly do not cover the range of aggregate materials or driving scenarios. It may be possible to find situations where the load shifts or settles in a non-symmetrical manner. However, the four trips did cover the materials that those who work with them judged most likely to shift. A review of the data suggests that the loads tend to settle uniformly, and directly downward; negligible shift was observed.

There is a wealth of anecdotal data on what is loosely referred to as "load shift." This may well mean the more general "load movement," using the definitions proposed in this report. It has been found that the distinction between load settlement and load shift is not generally made in conversation; however, this distinction is of the utmost importance for its effect on axle loads. It is reasonable to expect every load to settle. Symmetric shift may also occur, but is considered less likely. Asymmetric shift cannot be ruled out, but is regarded as even less likely. It is suggested that an operator's report of "load shift" is in fact load settlement most of the time. However, unless there are marks on the side of the trailer, perhaps from moisture in the load, it is suggested that movement of the magnitude seen in this experiment would be difficult for the unaided eye to judge within the size of the trailer.

It has been reported that one strategy for moving the load forward is to apply the brakes sharply while driving on a steep downgrade in the quarry. Clearly, at this early stage in the journey, little vibration will have been accumulated so the stones in the load may not have had much opportunity to lock together. It may, therefore, be easier to promote shift of a more significant part of the load by this means, at this stage of the journey, than it was during this experiment. A braking test was not proposed for this stage of the journey, so one was not conducted as part of this experiment. It is not likely such a scenario would occur often while driving in the quarry. It would most likely be a deliberate action by the driver to try and correct an excessive shift to the trailer axles after dumping off part of an overweight load.

A similar experiment was recently conducted by the Ministry of Transport of Quebec, but no report has been published. Their observations were essentially the same as those reported here: any load shift was minor and did not affect axle loads.

This experiment was not a comparison of methods of weighing. Nevertheless, it is worth noting that there was close agreement between the various weighings. The wheel scales provided very consistent axle unit weights and gross weights, when they could be used without interference with the weighing element. When there was interference, the reading was always low, or in favour of the truck operator. Gross weights were also consistent between wheel scales, MTO scales at truck inspection stations, and quarry platform scales. Differences between weighings among MTO wheel and platform scales were all well within the discretionary tolerance normally used by inspection staff before either axle or gross overweight charges would be laid. The results presented here are certainly not numerous enough to have statistical significance. They provide some assurance that weighing conducted by various parties, using various methods, at various places, is consistent.

6/ CONCLUSIONS

A limited experiment has examined movement of typical loads of aggregate materials that both aggregate producers and aggregate carriers jointly agree are most susceptible to shift. Each load was driven along a carrier's usual route in a normal manner from a quarry to a Ministry truck inspection station. It was then subjected to one abrupt stop at the inspection station.

The process of transportation appeared to cause each of the aggregate materials to settle relatively uniformly, without significant longitudinal shift. The abrupt stop produced only minor shifting at the upper level of the load.

None of the loads shifted sufficiently that axle weights were perceptibly affected.

It was concluded that the most likely cause of an axle overweight for an aggregate carrier within the allowable gross weight, and with the proper load on any liftable axle, would be the original load distribution, rather than load shift. An occasional occurrence of load shift that does affect axle loads cannot be ruled out on the basis of this limited experiment. The evidence, however, suggests it should be an infrequent exception, rather than the rule.

A video tape taken during this experiment has been edited to provide a narrated visual record of the observations upon which this report is based.

The various weighings conducted on each trip using portable scales, Ministry platform scales, and the aggregate producers platform scales, were in close agreement.

Table 1/ Load Profile for Trip 1
Petrella Transport with 3/4-inch Round Stone
Abrupt Stop 0.31 g

Stn	Load Height (m)					
	At Quarry		At TIS		After Stop	
	LHS	RHS	LHS	RHS	LHS	RHS
Head	0.74	0.85	0.74	0.86	0.86	0.86
2	1.14	1.21	1.07	1.14	1.14	1.13
3	1.42	1.36	1.36	1.31	1.37	1.31
4	1.26	1.35	1.23	1.30	1.23	1.30
5	0.86	1.14	0.86	1.10	0.86	1.13
6	0.69	0.97	0.76	0.94	0.75	0.95
7	0.56	0.86	0.58	0.86	0.58	0.86
8	0.37	0.81	0.46	0.79	0.47	0.79
9	0.08	0.55	0.17	0.52	0.23	0.56
10	0.00	0.15	0.00	0.14	0.00	0.13
Rear	0.00	0.00	0.00	0.00	0.00	0.00

Table 2/ Axle Loads for Trip 1

Location	Load (kg)			
	Steer Axle	Drive Axles	Trailer Axles	Gross
Quarry, wheel scales	5500	24 040	23 800	53 340
Quarry, platform scale				53 334
Victoria, wheel scales, on arrival	5400	24 240	24 160	53 800
Victoria, platform scale	5400	24 240	24 000	53 640
Victoria, wheel scales, after stop	5380	24 220	23 960	53 560

**Table 3/ Load Profile for Trip 2
Petrella Transport with Pea Stone
Abrupt Stop 0.31 g**

Stn	Load Height (m)							
	At Quarry		At TIS		After Stop		At Armbro	
	LHS	RHS	LHS	RHS	LHS	RHS	LHS	RHS
Head	0.77	0.79	0.80	0.81	0.89	0.84	0.88	0.81
2	1.14	1.12	1.10	1.10	1.14	1.09	1.13	1.09
3	1.37	1.41	1.32	1.33	1.32	1.33	1.32	1.31
4	1.33	1.40	1.32	1.35	1.32	1.35	1.30	1.32
5	1.30	1.12	1.24	1.12	1.24	1.13	1.24	1.14
6	1.19	1.08	1.13	1.05	1.14	1.04	1.12	1.04
7	0.95	0.94	0.90	0.90	0.94	0.89	0.91	0.89
8	0.58	0.61	0.61	0.61	0.60	0.62	0.58	0.60
9	0.14	0.20	0.18	0.23	0.18	0.22	0.18	0.22
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rear	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 4/ Axle Loads for Trip 2

Location	Load (kg)			
	Steer Axle	Drive Axles	Trailer Axles	Gross
Quarry, wheel scales	5580	24 300	23 360	53 240
Quarry, platform scale				53 216
Victoria, wheel scales, on arrival	5500	24 760	23 420	53 680
Victoria, platform scale	5430	24 790	23 350	53 570
Victoria, wheel scales, after stop	5480	24 660	23 420	53 560
Armbro, wheel scales	5500	24 860	23 160	53 520

Table 5/ Load Profile for Trip 3
Harold L. Wood Transport with 1/2-inch Pea Gravel
Abrupt Stop 0.36 g

Stn	Load Height (m)					
	At Quarry		At TIS		After Stop	
	LHS	RHS	LHS	RHS	LHS	RHS
Head	0.08	0.20	0.08	0.20	0.23	0.28
2	0.48	0.66	0.46	0.62	0.46	0.61
3	0.71	0.97	0.70	0.90	0.69	0.90
4	0.76	1.04	0.74	0.99	0.75	0.99
5	0.61	0.91	0.61	0.89	0.60	0.91
6	0.79	0.94	0.79	0.91	0.79	0.91
7	0.85	1.05	0.86	1.02	0.85	1.00
8	0.83	1.03	0.83	0.97	0.81	0.97
9	0.64	0.88	0.64	0.81	0.64	0.81
10	0.33	0.48	0.33	0.46	0.29	0.51
Rear	0.00	0.00	0.00	0.09	0.00	0.10

Table 6/ Axle Loads for Trip 3

Location	Load (kg)			
	Steer Axle	Drive Axles	Trailer Axles	Gross
Quarry, wheel scales	6080	22 240	22 460	50 780
Quarry, platform scale				52 082
Bowmanville, wheel scales, on arrival	6200	23 400	22 720	52 320
Bowmanville, platform	6220	23 310	22 620	52 150
Bowmanville, wheel scales, after stop	6120	23 540	22 780	52 440

Table 7/ Load Profile for Trip 4
Harold L. Wood Transport with 3/4-inch Round Stone
Abrupt Stop 0.39 g

Stn	Load Height (m)					
	At Quarry		At TIS		After Stop	
	LHS	RHS	LHS	RHS	LHS	RHS
Head	0.30	0.48	0.33	0.46	0.47	0.46
2	0.44	0.81	0.66	0.77	0.71	0.76
3	0.86	1.00	0.84	0.97	0.84	0.94
4	0.79	1.02	0.77	0.98	0.77	0.98
5	0.52	0.90	0.53	0.89	0.55	0.89
6	0.53	0.91	0.53	0.89	0.57	0.90
7	0.56	0.90	0.56	0.88	0.57	0.88
8	0.61	0.88	0.58	0.84	0.58	0.84
9	0.36	0.58	0.41	0.61	0.42	0.62
10	0.04	0.46	0.05	0.46	0.05	0.44
Rear	0.00	0.19	0.00	0.20	0.00	0.11

Table 8/ Axle Loads for Trip 4

Location	Load (kg)			
	Steer Axle	Drive Axles	Trailer Axles	Gross
Pit, wheel scales	6260	21 840	23 440	51 540
Pit, pit scale				52 408
Bowmanville, wheel scales, on arrival	5880	22 440	24 320	52 660
Bowmanville, platform	6130	22 060	24 320	52 510
Bowmanville, wheel scales, after stop	5960	22 360	24 260	52 580

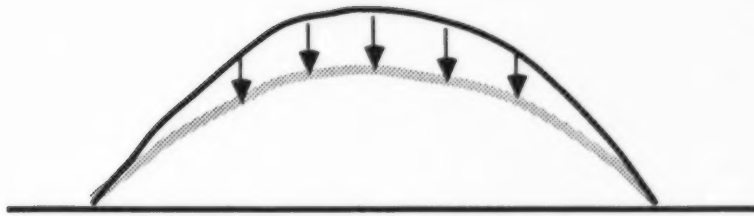


Figure 1/ Load Settlement



Figure 2/ Symmetric Load Shift



Figure 3/ Asymmetric Load Shift

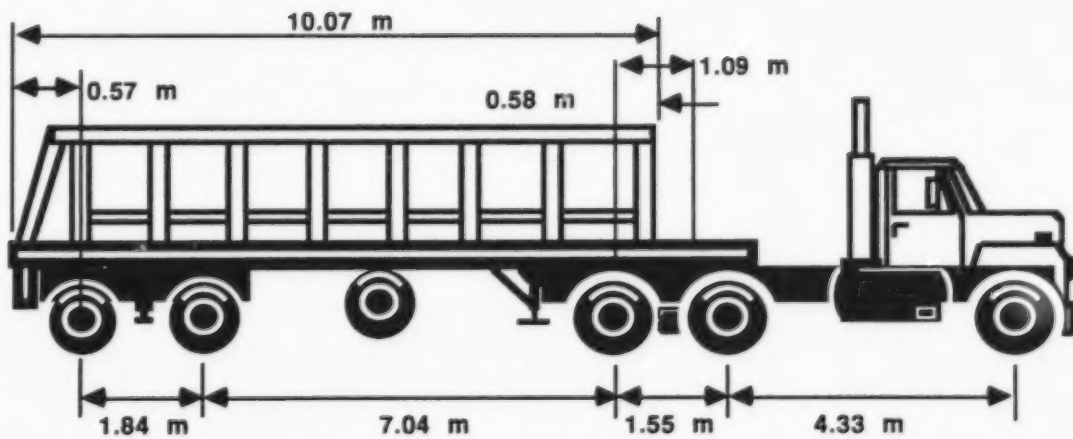
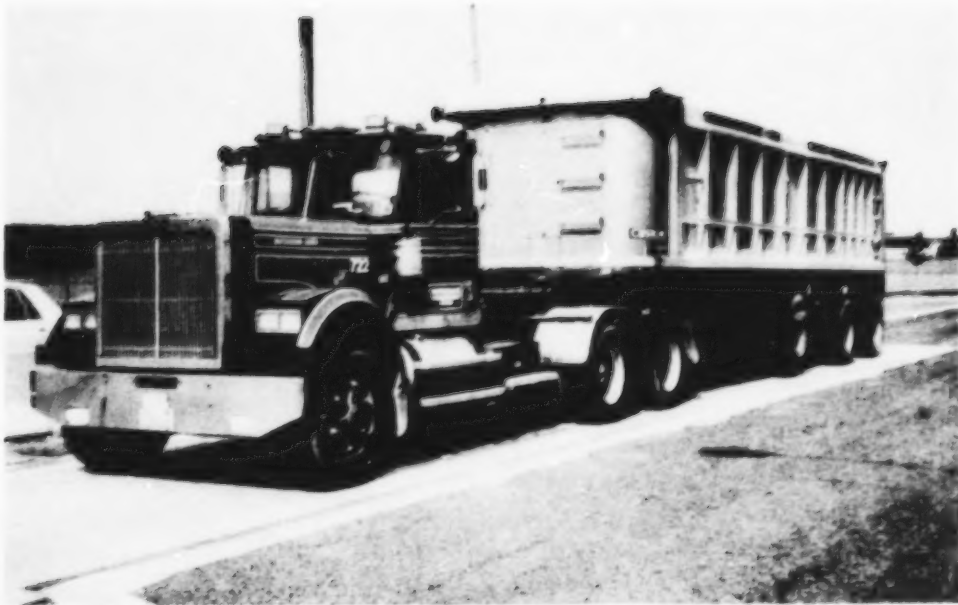


Figure 4/ Petrella Transport Vehicle

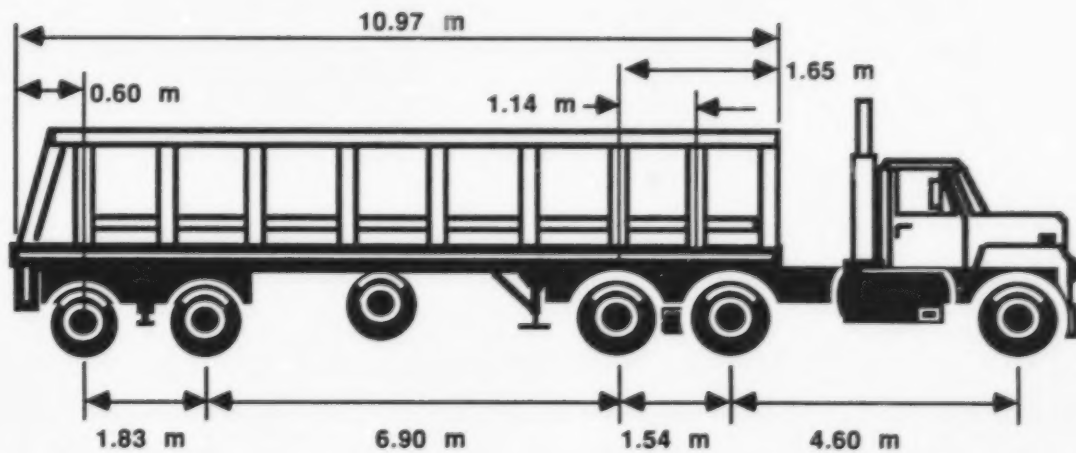


Figure 5/ Harold L. Wood Transport Vehicle

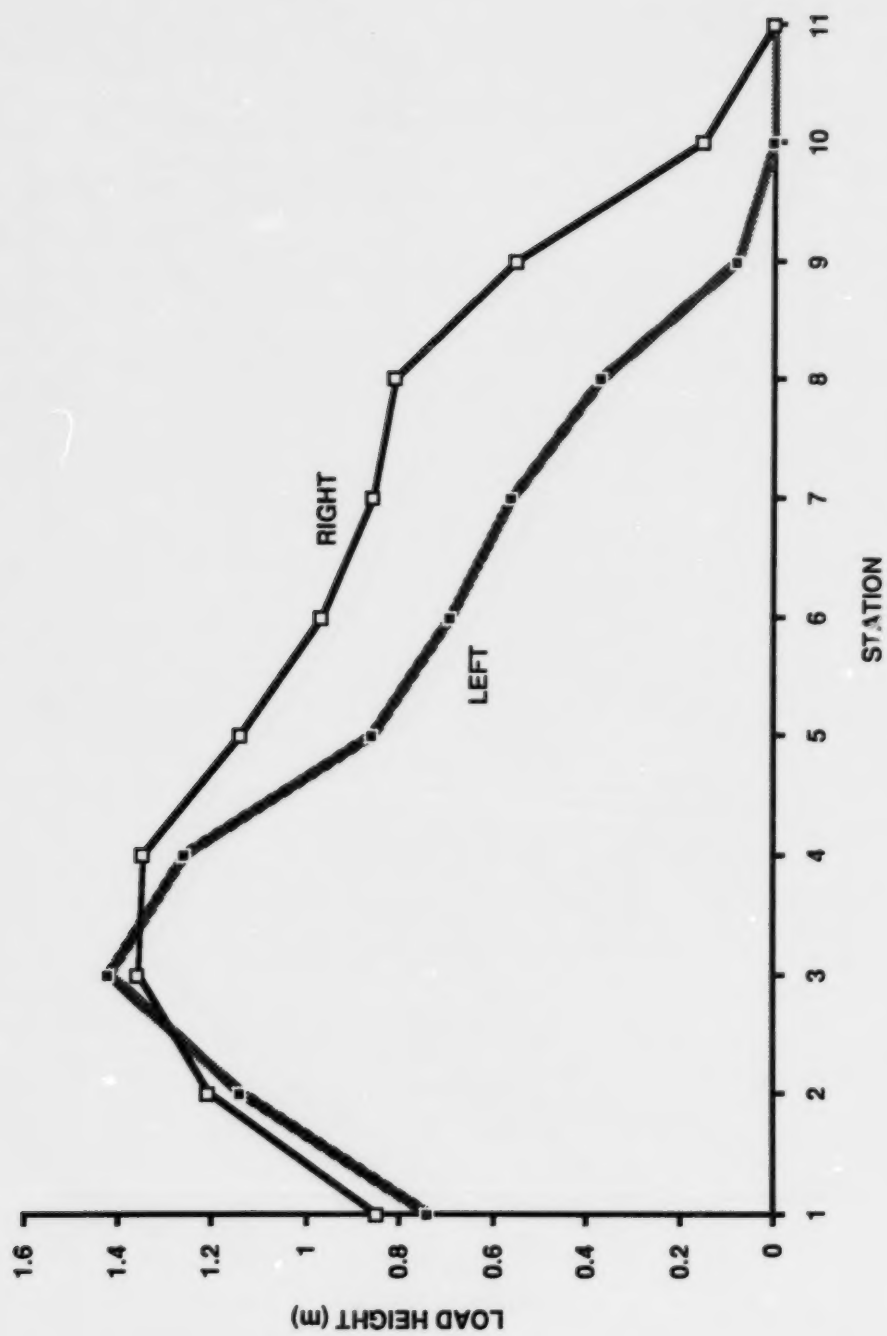


Figure 6/ Load Profile, Petrella Transport, Trip 1

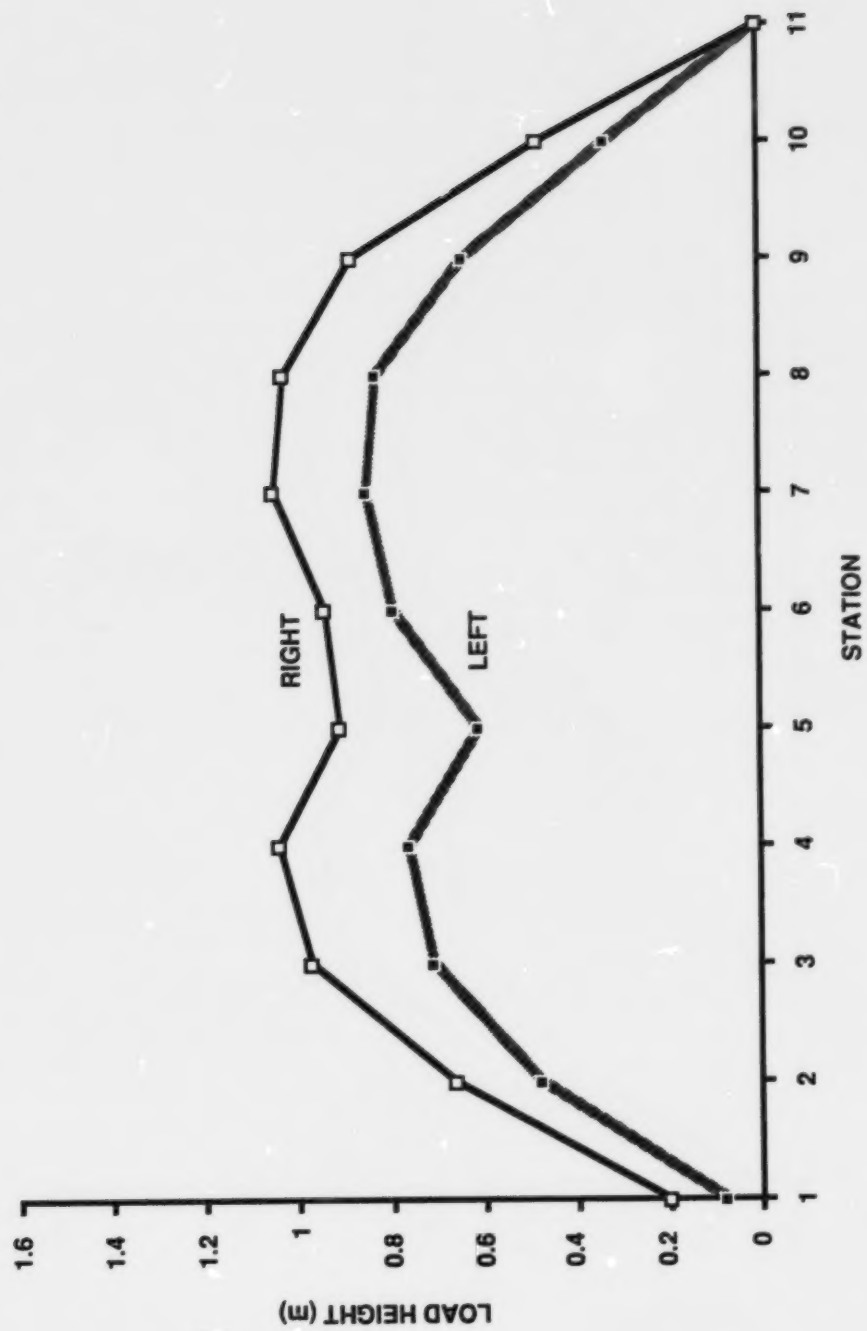


Figure 7/ Load Profile, Harold L. Wood Transport, Trip 3



Figure 8/ Loading the Truck, Trip 4



Figure 9/ Weighing the Truck, Trip 2



Figure 10/ Measuring the Load Profile



Figure 11/ Marking the Load Profile

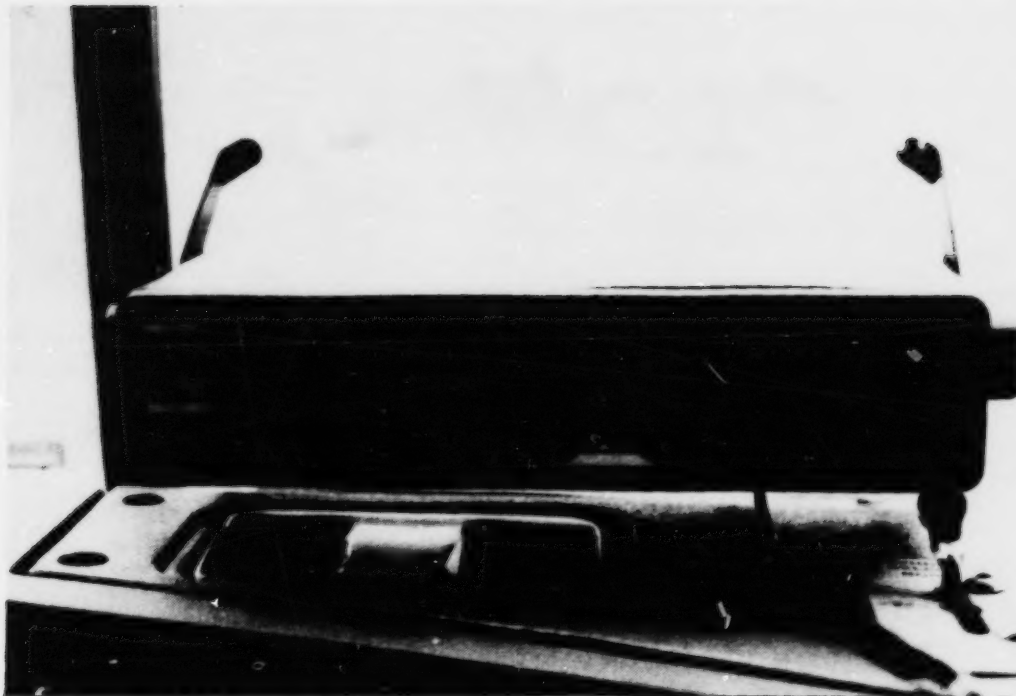


Figure 12/ Braking Decelerometer Attached to Truck Windshield



Figure 13/ Video-taping and Measuring the Load Profile, Trip 3

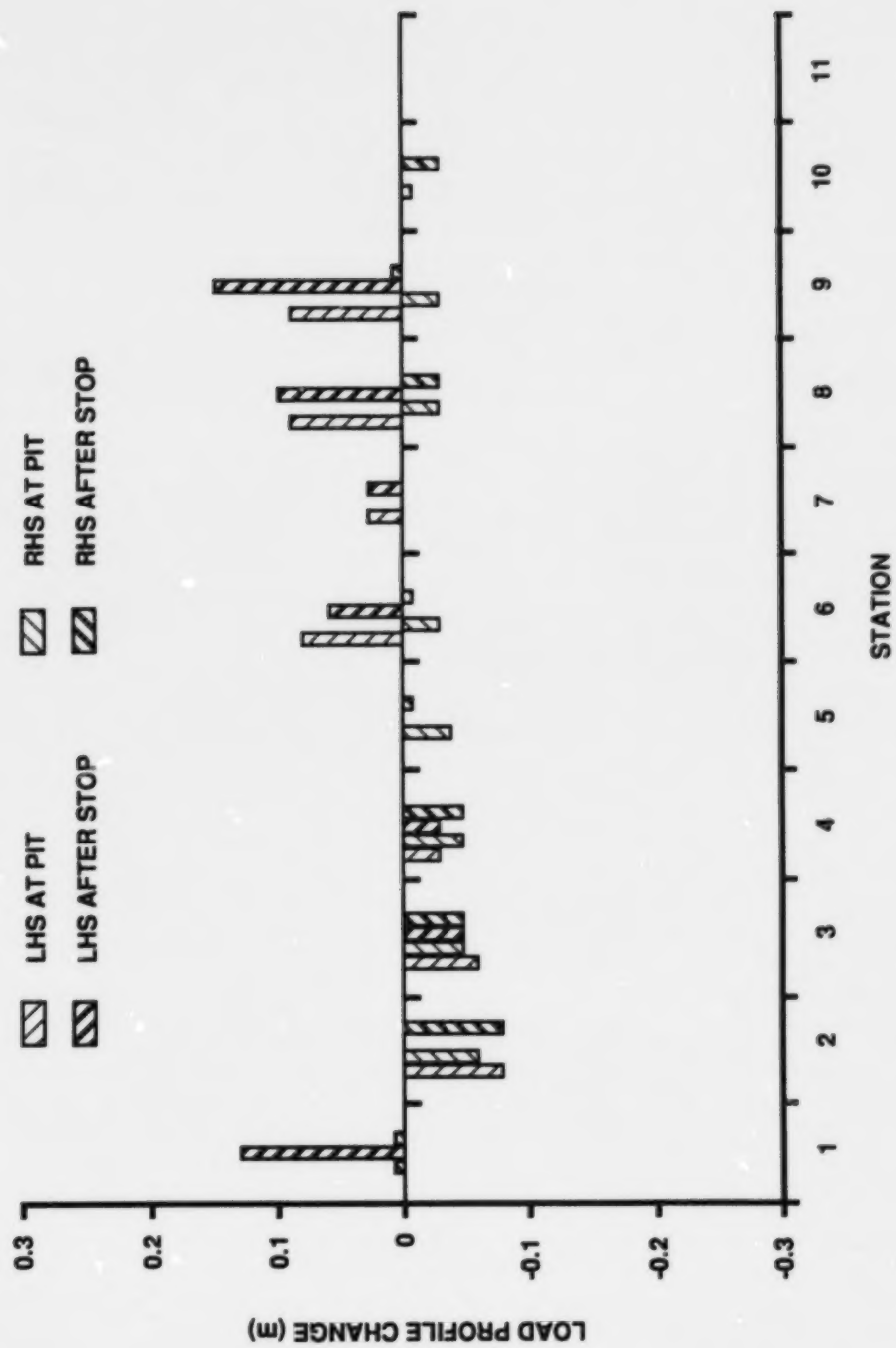


Figure 14/ Load Profile Change, Trip 1

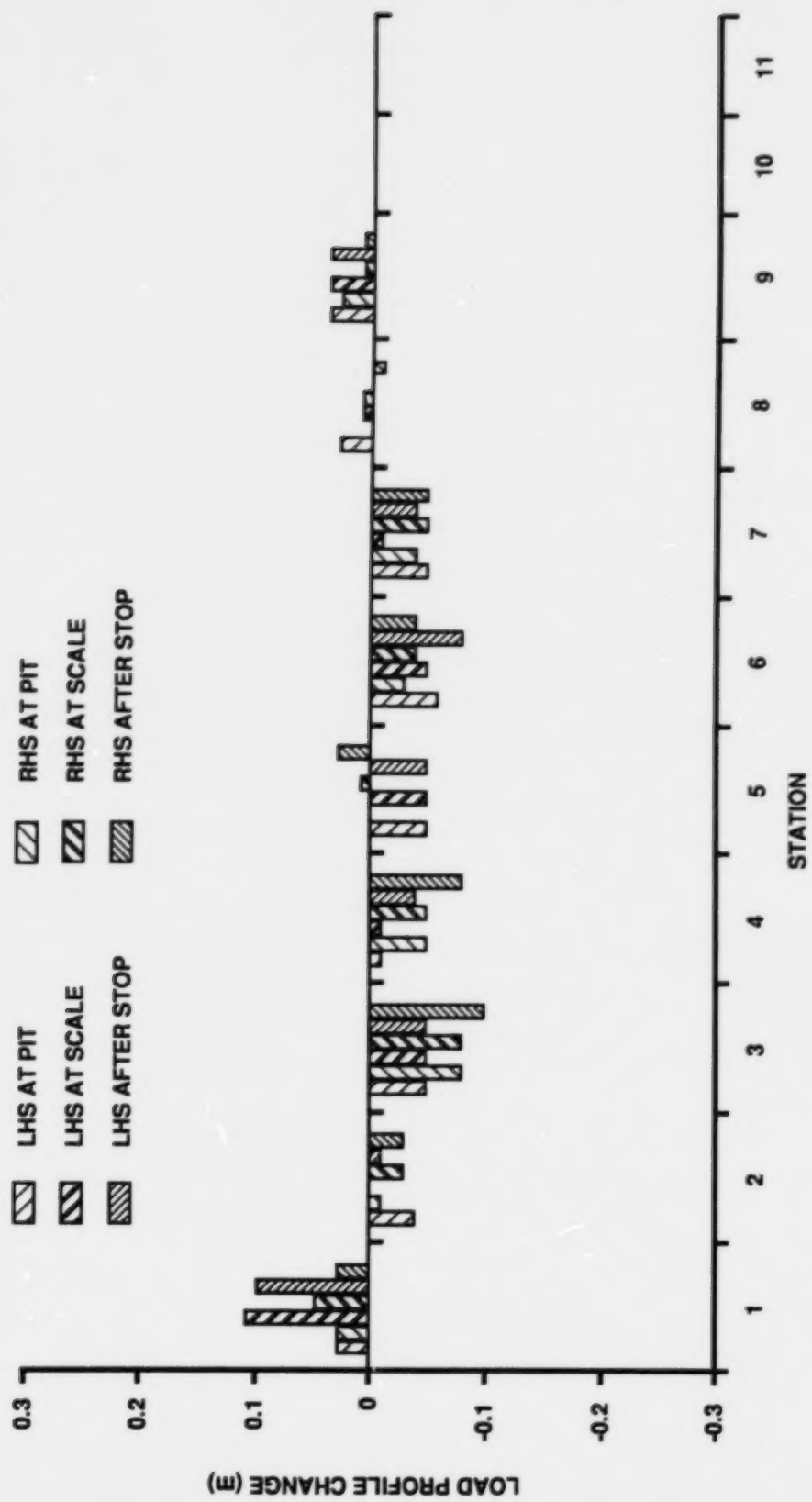


Figure 15/ Load Profile Change, Trip 2

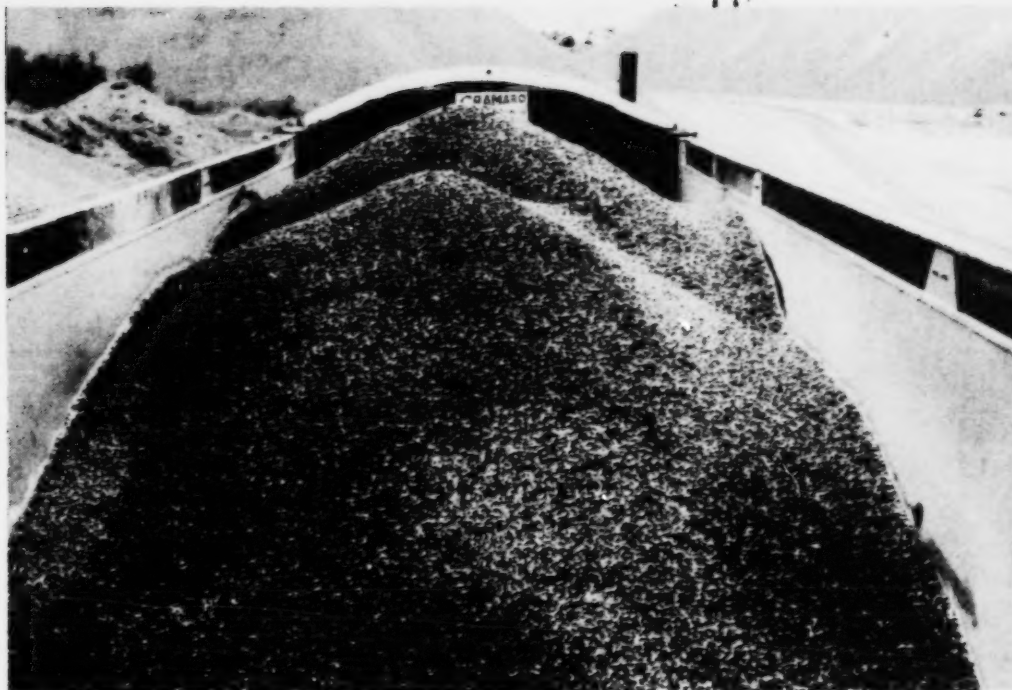


Figure 16/ Load Profile Immediately After Loading, Trip 2



**Figure 17/ Load Profile on Arrival at Victoria Truck Inspection Station,
Trip 2**

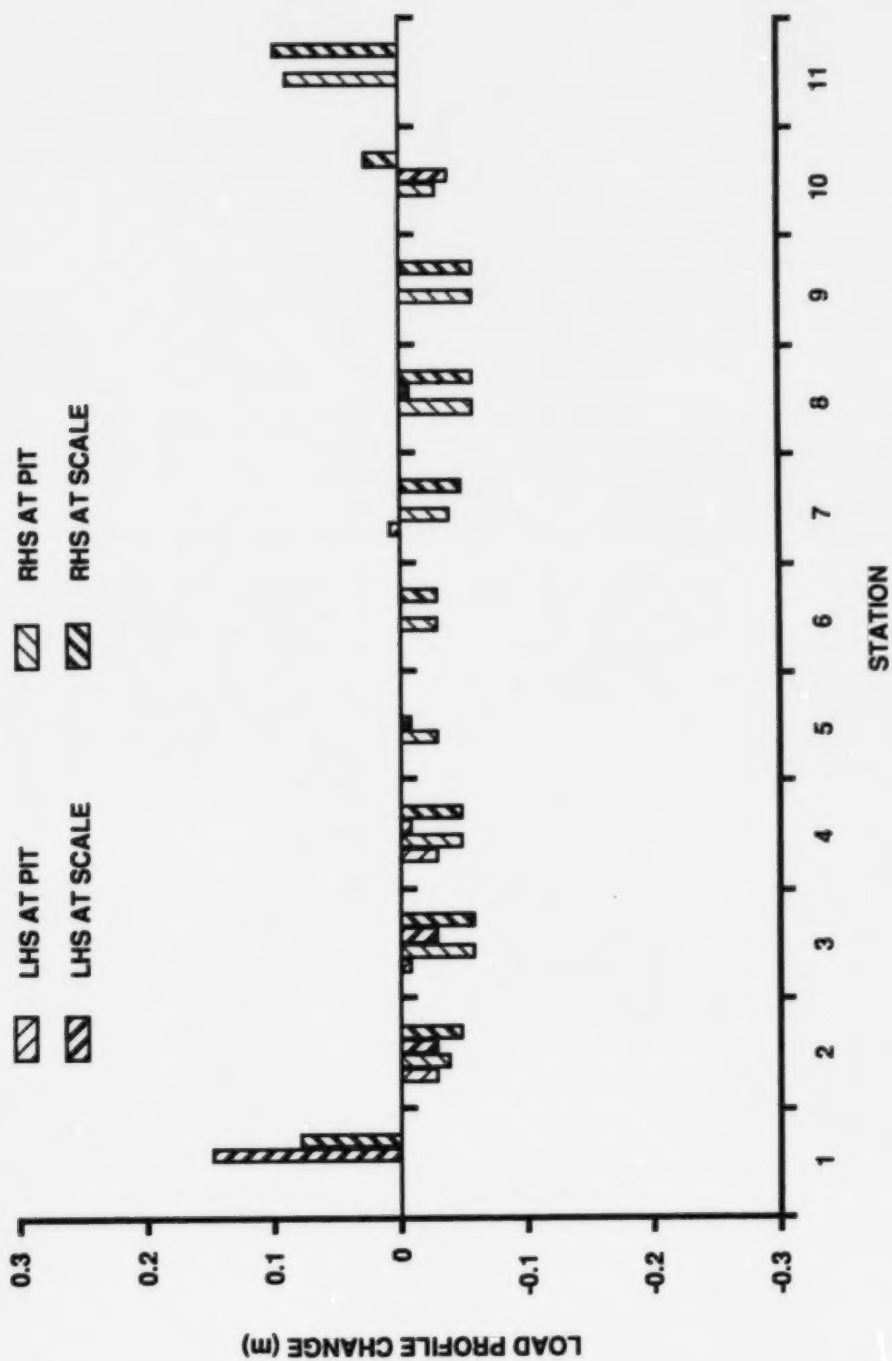


Figure 18/ Load Profile Change, Trip 3



Figure 19/ Dumping the Load, Trip 3



Figure 20/ Typical Load Shift at Front of Trailer Due to an Abrupt Stop, Trip 4

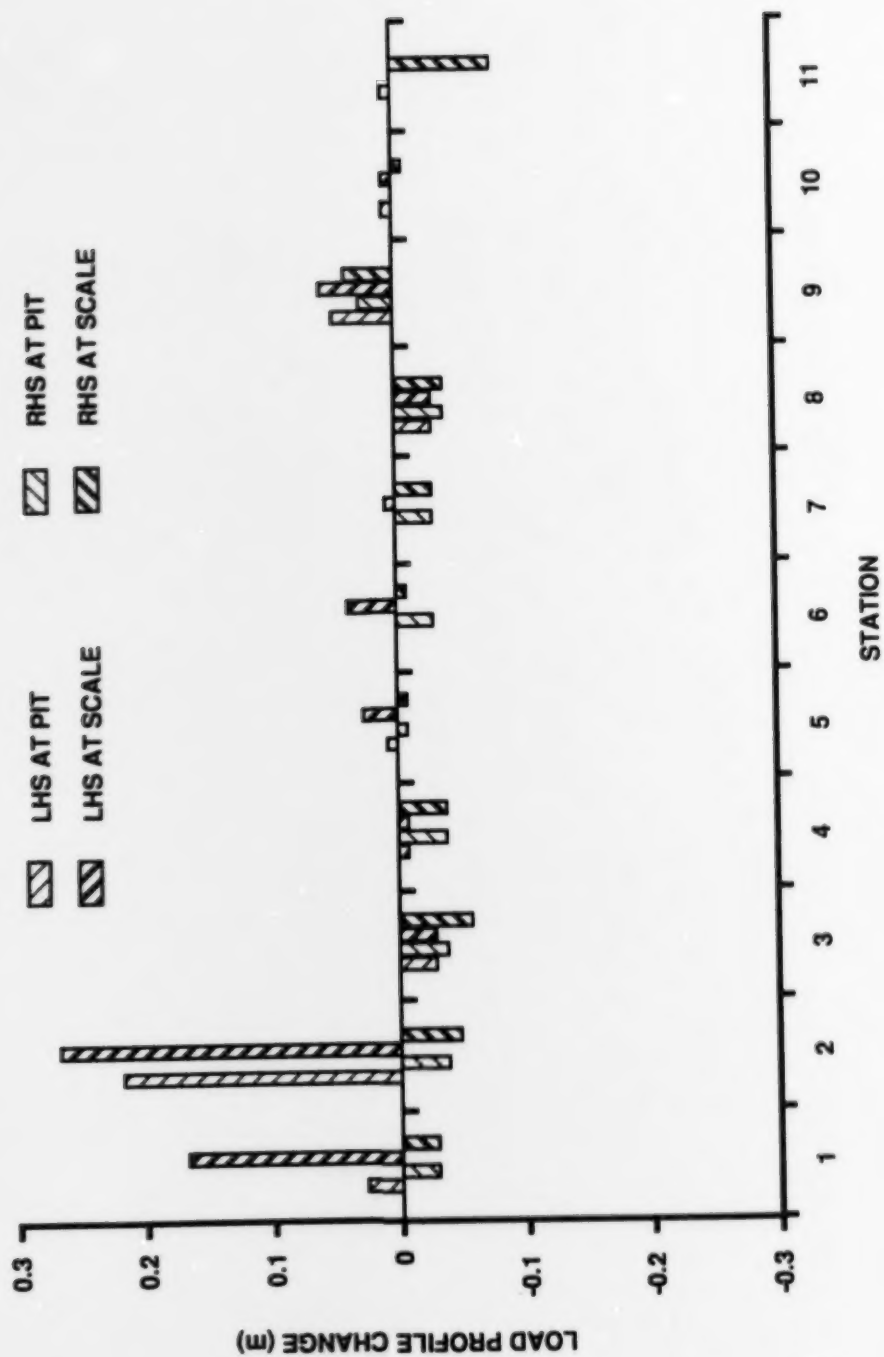


Figure 21/ Load Profile Change, Trip 4